P1.1 REDUCED HORIZONTAL SEA SURFACE TEMPERATURE GRADIENTS UNDER CONDITIONS OF CLEAR SKY AND WEAK WINDS

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1. INTRODUCTION

When interpreting satellite derived sea surface temperatures (SSTs), one must often integrate information obtained from other satellites or in-situ data for correct interpretation. In the case of weak surface wind speed, less than approximately 5 m/s and a clear sky with strong insolation, two effects can occur that may lead to misinterpretations:

a) A shallow layer of warmed water near the sea surface can develop, which makes the SSTs not representative of the bulk of the mixed layer of the ocean.

b) In addition, if horizontal temperature gradients exist in the surface water, the simultaneous cooling from the sea surface by evaporation, sensible heat loss, and longwave radiation would be larger from the warmer water than from the cooler side of the gradient associated with features such as fronts or eddies, leading to greater net heating on the cool side. This results in a reduction in the horizontal temperature gradients and erroneous inferences about the mixed layer (Katsaros *et al.,* 1983; Katsaros and Soloviev, 2003), which may have consequences for fishing and other activities.

We illustrate these two effects with data from the Florida Straits and from model calculations of the phenomenon in b) based on mean measurements from a mooring array deployed on the shelf off southeast Florida. This mooring array is primarily intended for monitoring the coastal circulation and environmental conditions (Soloviev *et al.,* 2003, in press). Figure 1 shows hydro-meteorological and radiation conditions during the 2000 Summer Experiment. The diurnal peak of solar radiation flux reached 1000 W m^{-2} (Figure 1e). When wind speed dropped below ~5 m s^{-1}, a strong diurnal warming of the near-surface layer of the ocean occurred (Figures 1a and 1b).

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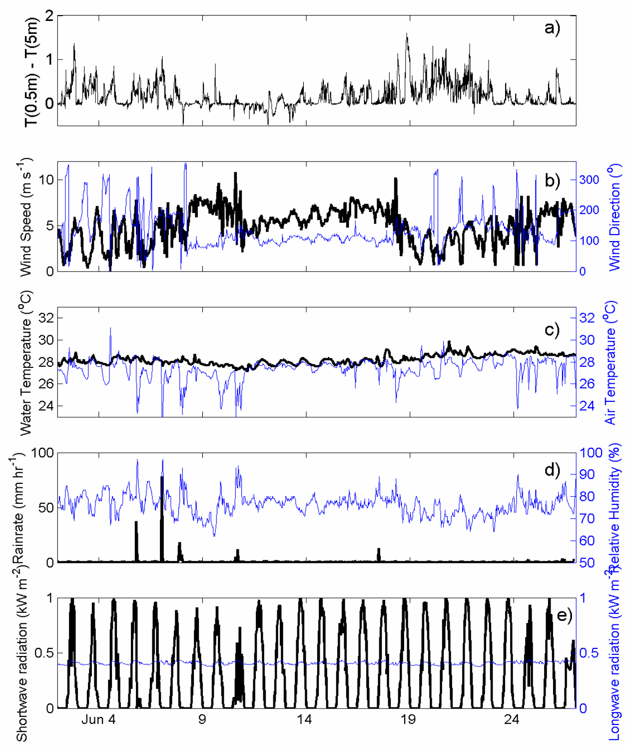

Figure 1. Hydro-meteorological and radiation conditions during Summer 2000 Experiment on the shelf off southeast Florida: (a) temperature difference between 0.5 and 5-m depth; (b) wind speed (bold line) and wind direction; (c) water temperature (bold line) and air temperature; (d) rain rate (bold line) and relative humidity; (e) solar insolation (bold line) and downwelling longwave radiation. Data set from plate (a) is from the surface mooring at a 20-m isobath; data sets from plates (b)-(e) are from the nearby surface mooring deployed at a 50-m isobath.

2. REDUCTION IN HORIZONTAL TEMPERATURE GRADIENTS

We solve the diffusion equation in one dimension for the uppermost layers of the sea with a 0.25 m vertical resolution taking into account wind stress and consequent effects on mixing (affecting turbulent diffusion coefficients in the sea) for momentum, heat, and mass. We account for insolation absorption as a function of depth and heat losses from sea to air, as calculated by bulk aerodynamic formulas (see Katsaros and Soloviev, 2003, for details).

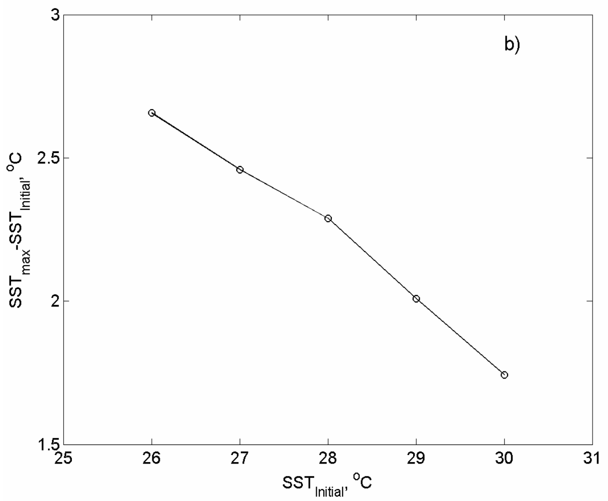

Figure 2. Dependence of the change in SST on the initial temperature. Modeling parameters are representative of the Gulf of Mexico and Florida Straits cases, wind speed 2 m s^{-1}, specific humidity 16 g Kg^{-1}, and air temperature 28°C.

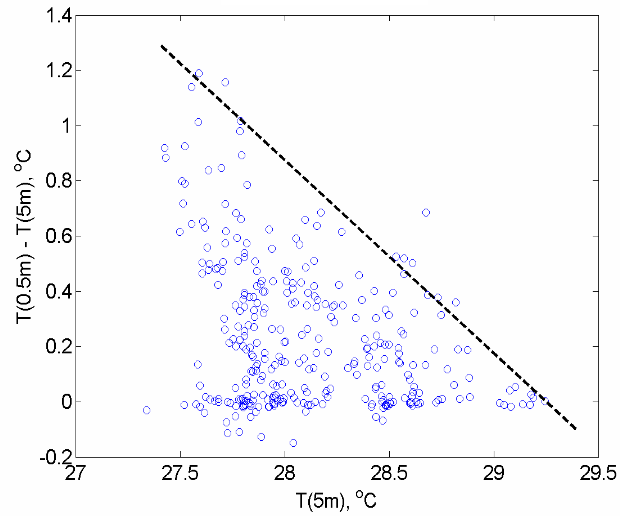

Figure 3. Dependence of the temperature difference between 0.5 m and 5 m on the temperature at 5-m depth for 25 days in June 2000 under no rain conditions.

The calculation illustrated in Figure 2 represents a hypothetical case in the Florida Straits. It shows the change in surface temperature for five initial temperatures in the range from 26 to 30°C. The colder water always warms more than the warmer water, as indicated by the negative slope of the line.

For a situation representative of the subtropical region around Florida, we find the following result: For constant atmospheric and insolation conditions as air flows over water varying in temperature from 26 to 30°C, the SST of the cooler water warms consistently more than the warmer water (Figure 2). This is an obvious consequence of the dependence of all the heat loss terms on SST, namely latent heat flux, sensible heat flux and net longwave radiation to the atmosphere and space.

Figure 3 shows the temperature difference between 0.5 m and 5 m depth during the experiment in the Florida Straits (Figure 1) as a function of the temperature at a 5-m depth. Temperatures from an instrument at 5-m depth serve as an indicator of the bulk mixed layer temperature. To some extent, it is analogous to the initial temperature ($SST_{initial}$) in our modeling effort presented in Figure 2, while the temperature measured at a depth of 0.5 m approximates the model SST.

The field data (Figure 3) clearly demonstrates the same tendency of the waters with cooler bulk mixed layer to have a larger diurnal temperature difference across the upper 4.5 m layer of the ocean and thus to compensate for the difference in SST between different water masses.

3. DISCUSSION

For the exact diurnal amount of increase in SST and reduction in SST gradients in any particular situation, one must perform this calculation with the appropriate upper ocean mixing and the complete stratification effects and variations in the atmospheric fluxes as air flows from warm to colder, or colder to warmer water, or parallel to the SST gradients, etc. Any advection in the water should also be accounted for, although it is typically not very large over one day.

This example is only indicative of the situations that one would encounter in many summer time situations at high latitudes and much of the year at low latitudes, whenever the wind speed is relatively weak and the net diurnal heat flux results in heating of the upper ocean.

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REFERENCES

Katsaros, K. B., A. Fiuza, F. Sousa, and V. Amann, 1983: Sea surface temperature patterns and air-sea fluxes in the German Bight during MARSEN 1979, Phase I. *J. Geophys. Res.*, **88**, 9871-9882.

Katsaros, K. B., and A. V. Soloviev, 2003: Vanishing horizontal sea surface temperature gradients at low wind speeds. *Bound.-Layer Met.* (in press).

Soloviev, A., R. Walker, R. Weisberg, and M. Luther, 2003: Coastal observatory investigates energetic current oscillations on the southeast Florida Shelf. *EOS, Transactions, AGU* (in press).